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# Temporal Production Profiles of Wind Power Plants in California and Other Western States

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California and Interstate Renewable Resources

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# Project Goals

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1. To assess the importance of temporal variations in wind output in determining the value of wind power at different wind resource sites in California and throughout the West
2. To address the question of whether wind resource sites outside of CA are a better or worse match to CA's electricity load and prices than are wind resource sites within the state
3. To help identify hourly wind production data sources that might be used in modeling work

## **IMPORTANT NOTE**

Analysis focused on only one element of the value equation:  
**temporal production profiles**

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# Project Work Scope

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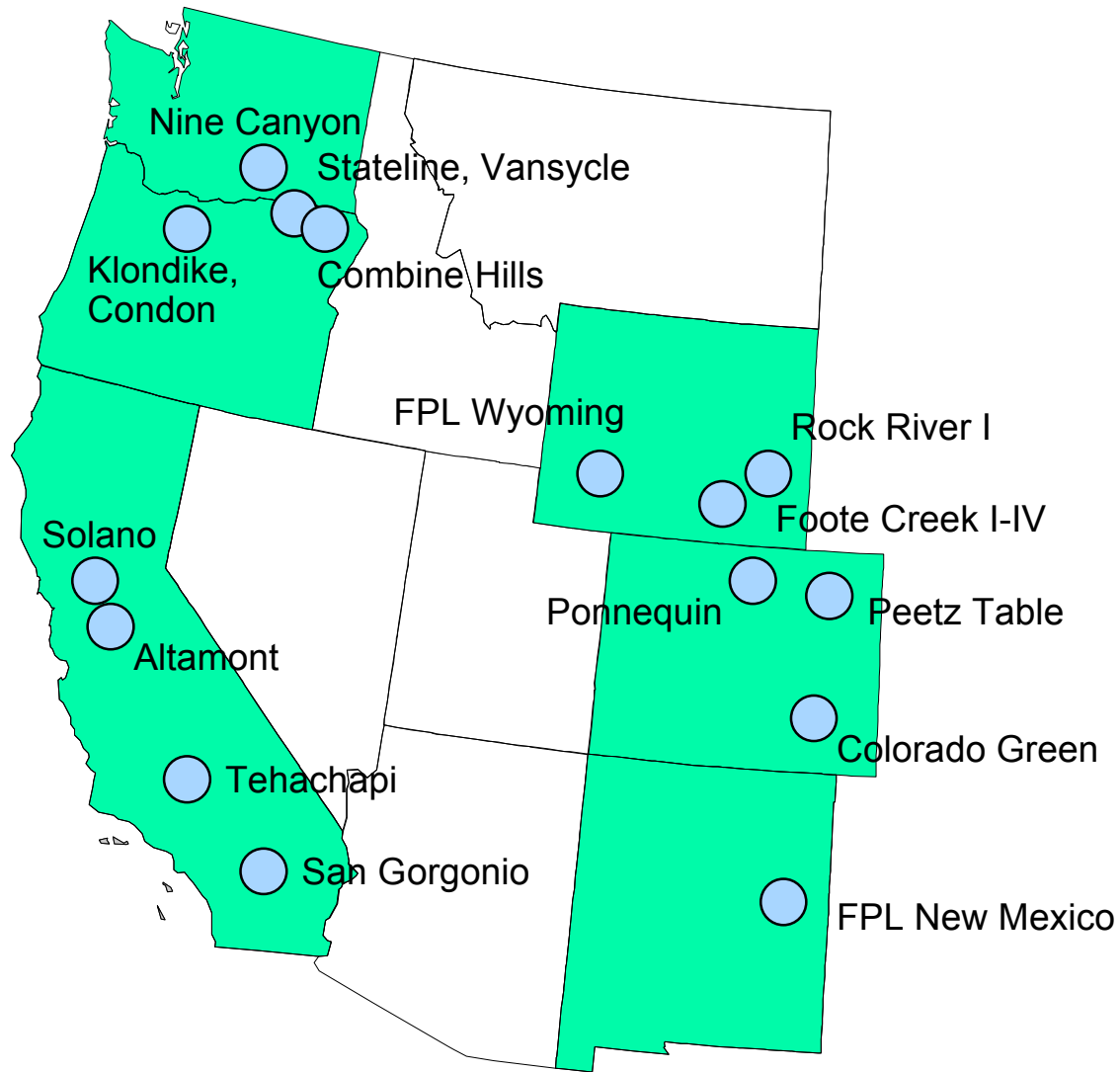
1. **Data Compilation and Summary:** Compile and summarize information on temporal wind speed and power production patterns throughout the West
    - Actual production from operating wind power projects
    - Wind power production estimates from developers
    - Anemometer wind-speed data
    - TrueWind modeled wind-speed estimates
  2. **Berkeley Lab Report:** Review draft report that analyzes the correlation of temporal wind production with wholesale market prices and electrical load in CA and the Northwest
    - Fripp, M. and R. Wiser. 2005 (forthcoming). “Analyzing the Effect of Temporal Wind Patterns on the Value of Wind-Generated Electricity at Different Sites in California and the Pacific Northwest.”
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# Key Findings of the Data Compilation: Temporal Wind Profiles

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- Existing CA sites are generally spring-summer peaking (April - July), with strong diurnal profiles that peak in the late evening (around midnight) and drop to a low in the late morning (11:00-12:00 am)
  - Sites in other parts of the West often experience strong winter peaks (WY), lower monthly variation but some tendency for fall-winter-spring peaks (CO, NM, ID, MT), or mixed monthly profiles with some summer-peaking resources and other winter peaking resources (OR, WA, NV)
  - Diurnal variation outside of CA is typically less pronounced, with “weather-driven” resources, and many sites have more attractive diurnal profiles than the CA sites
  - There is no broad resource area located outside of CA that clearly has a **dramatically better** profile relative to CA’s summer-afternoon peaking demands: CA’s wind resources more closely match CA’s summer peak loads, but often have a relatively poor diurnal pattern
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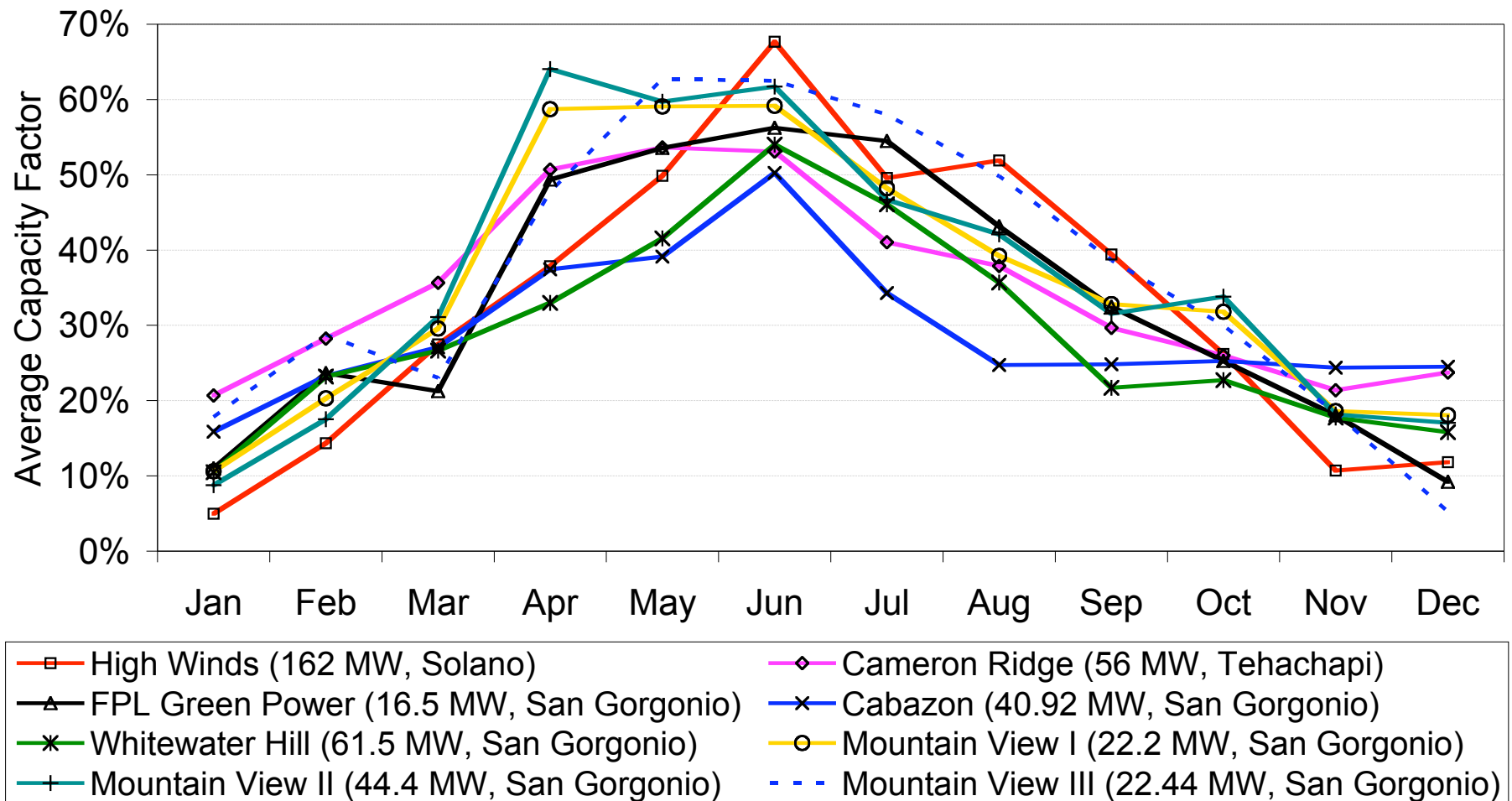
# Production Data from Operating Wind Projects in the West



Collected temporal wind profile data from operating wind power projects, anemometers, and project developer projections

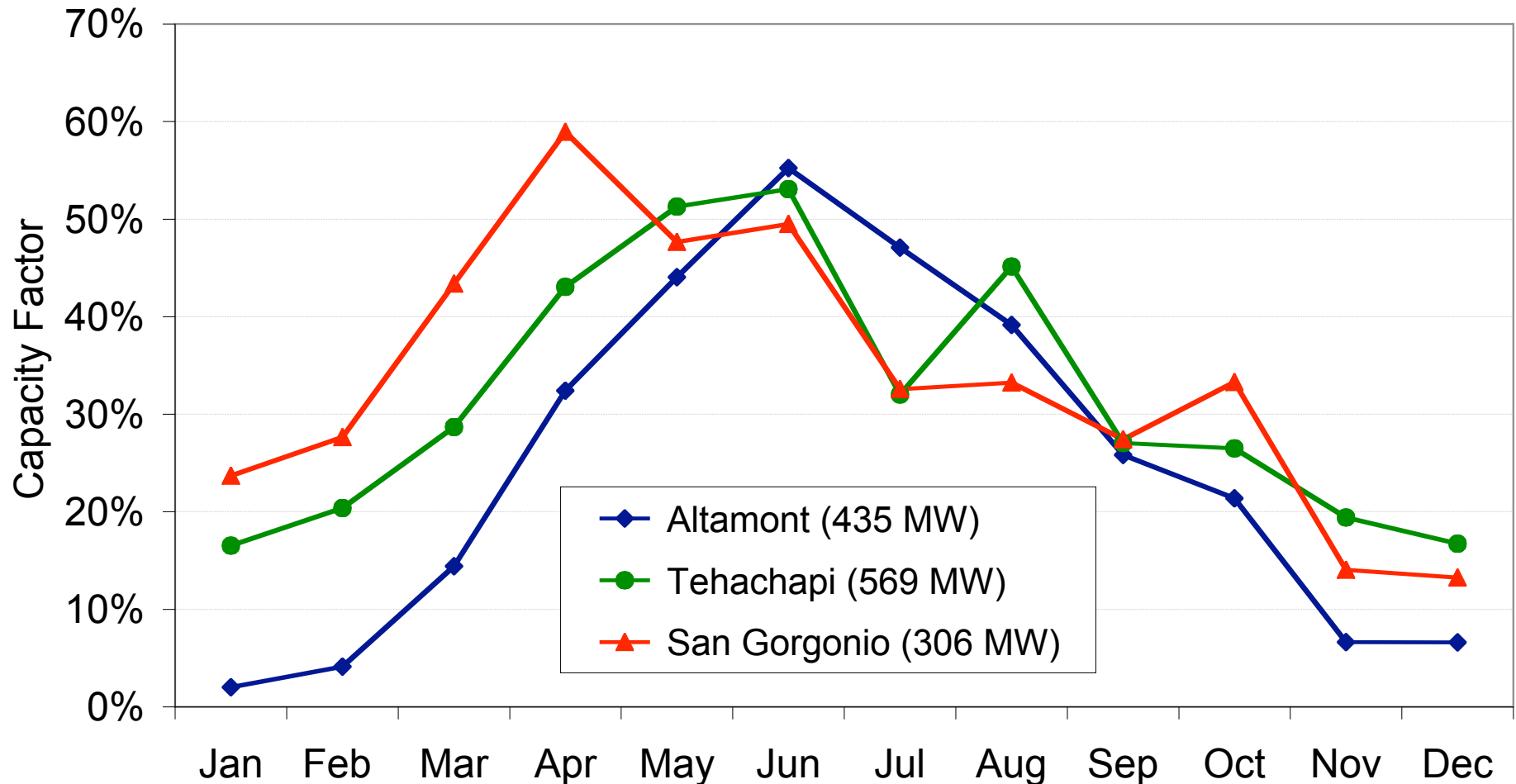
Seven slides that follow summarize *only* actual production data from operating wind projects; projects included in our sample are those shown in the map to the left

# California Monthly Profiles (Actual Production, by Project)



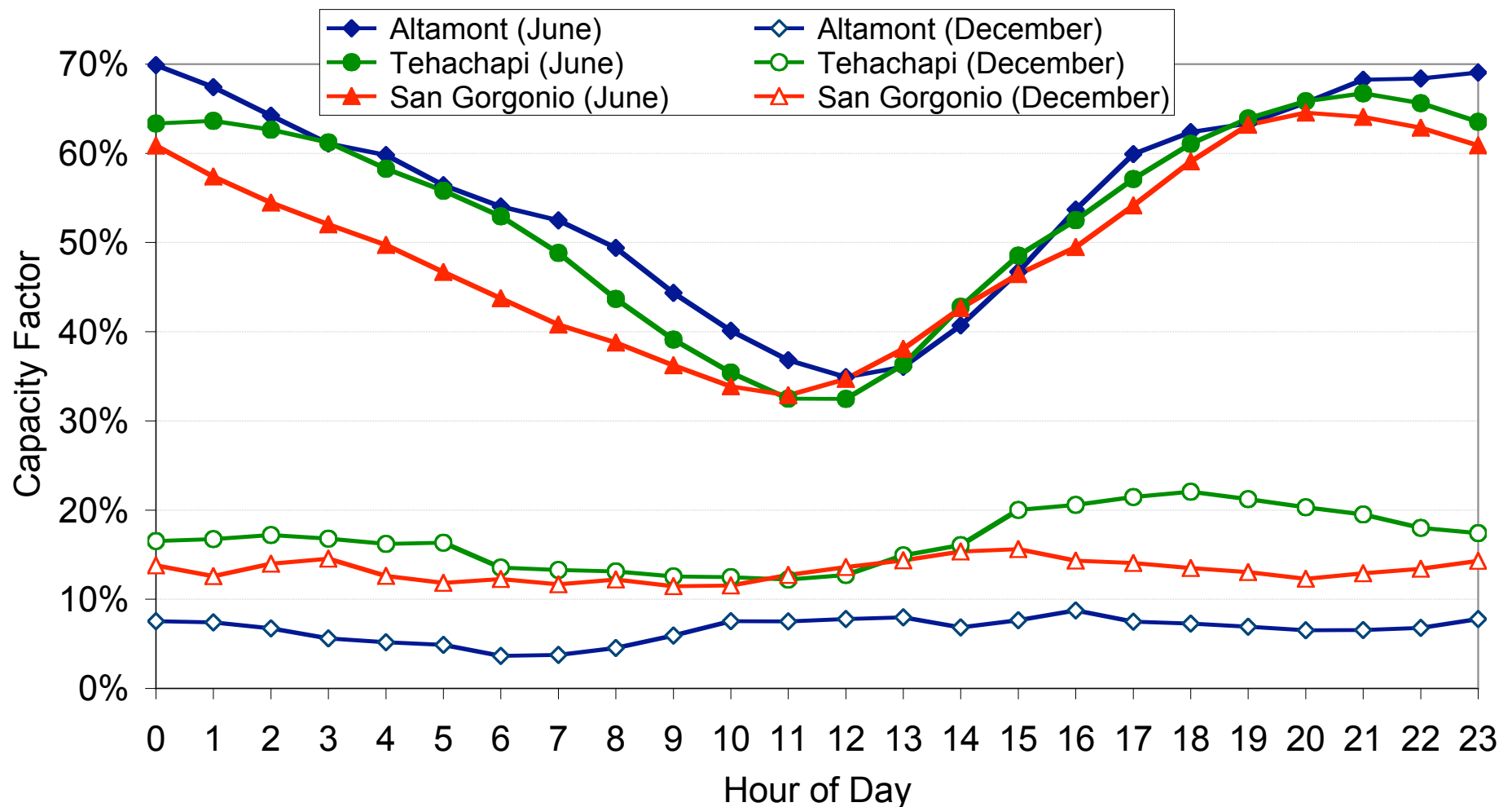
Source: Project filings to FERC and EIA; 1-3 years of data for each site, through 2004

# California Monthly Profiles (Actual Production, by Resource Area)



*Source: Actual production data for 2002, from the CA ISO,  
and used in the Energy Commission's integration cost work*

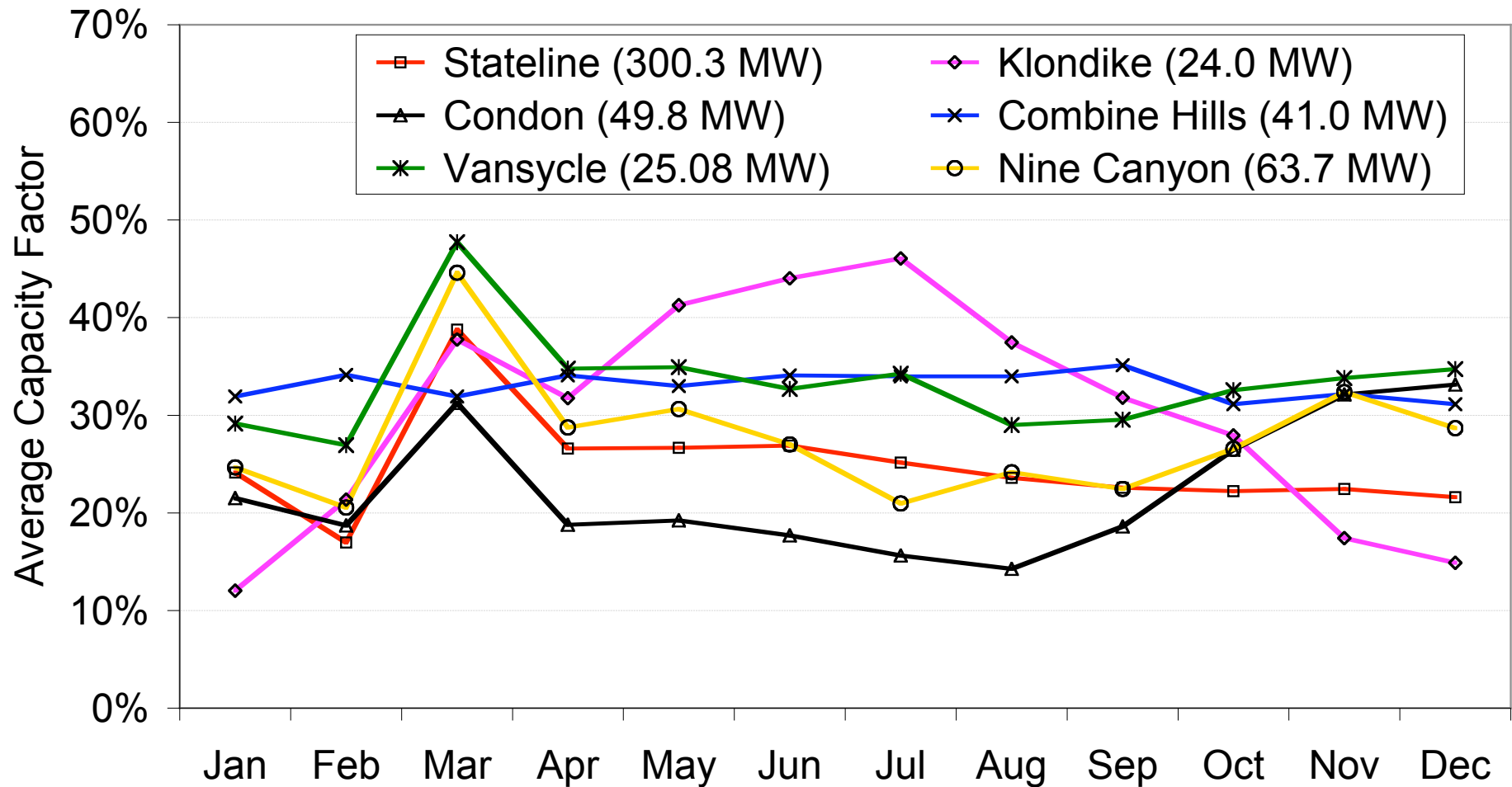
# California Diurnal Profiles for June and December (Actual Production, by Resource Area)



Source: Actual production data for 2002, from the CA ISO,  
and used in the Energy Commission's integration cost work

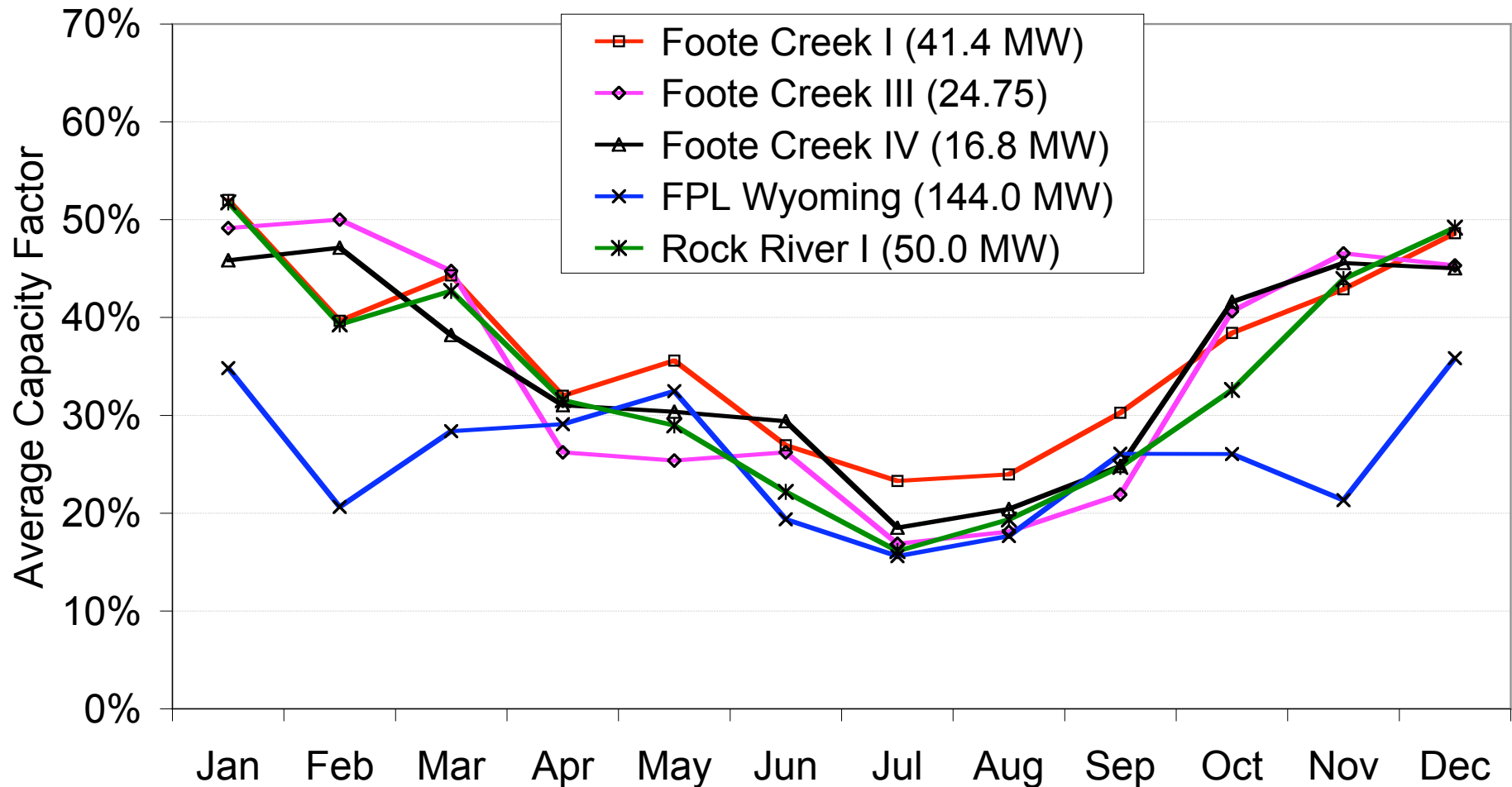


# Oregon and Washington Monthly Profiles (Actual Production, by Project)



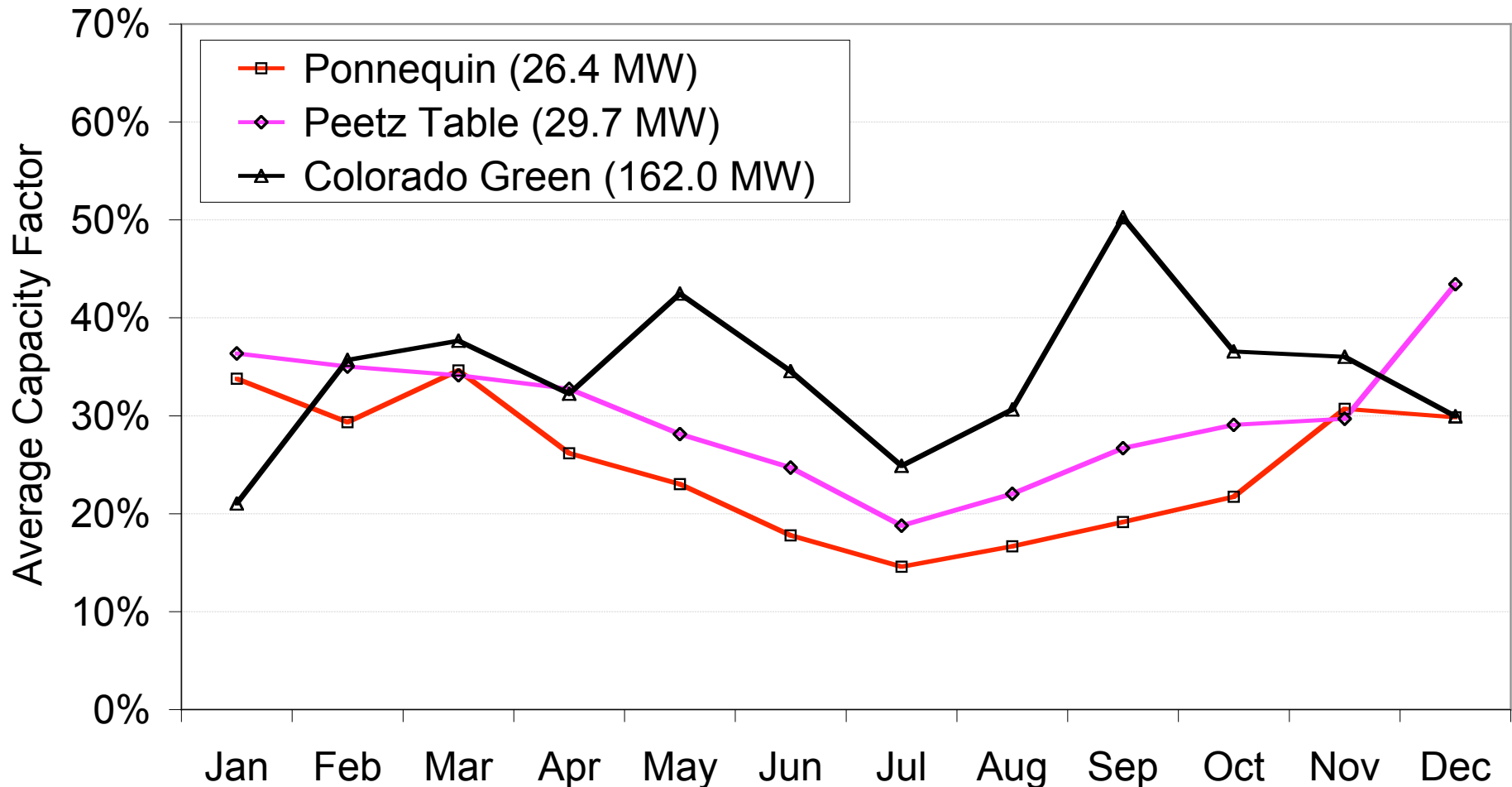
Source: Project filings to FERC and EIA; 1-4 years of data for each site, through 2004

# Wyoming Monthly Profiles (Actual Production, by Project)



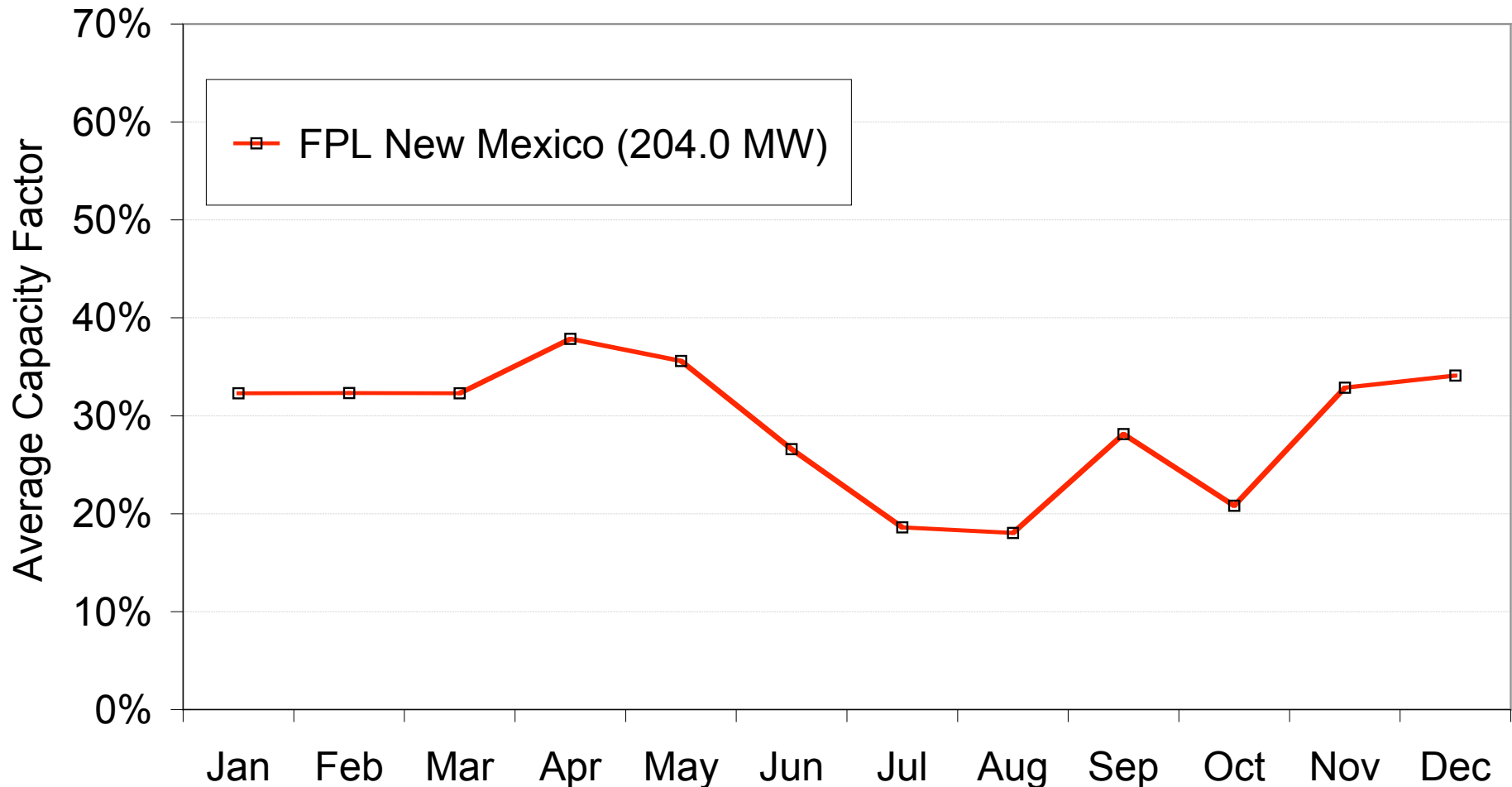
Source: Project filings to FERC and EIA; 1-4 years of data for each site, through 2004

# Colorado Monthly Profiles (Actual Production, by Project)



*Source: Project filings to FERC and EIA; 1-3 years of data for each site, through 2004*

# New Mexico Monthly Profiles (Actual Production, by Project)



*Source: Project filings to FERC and EIA; 1.3 years of data for site, through 2004*

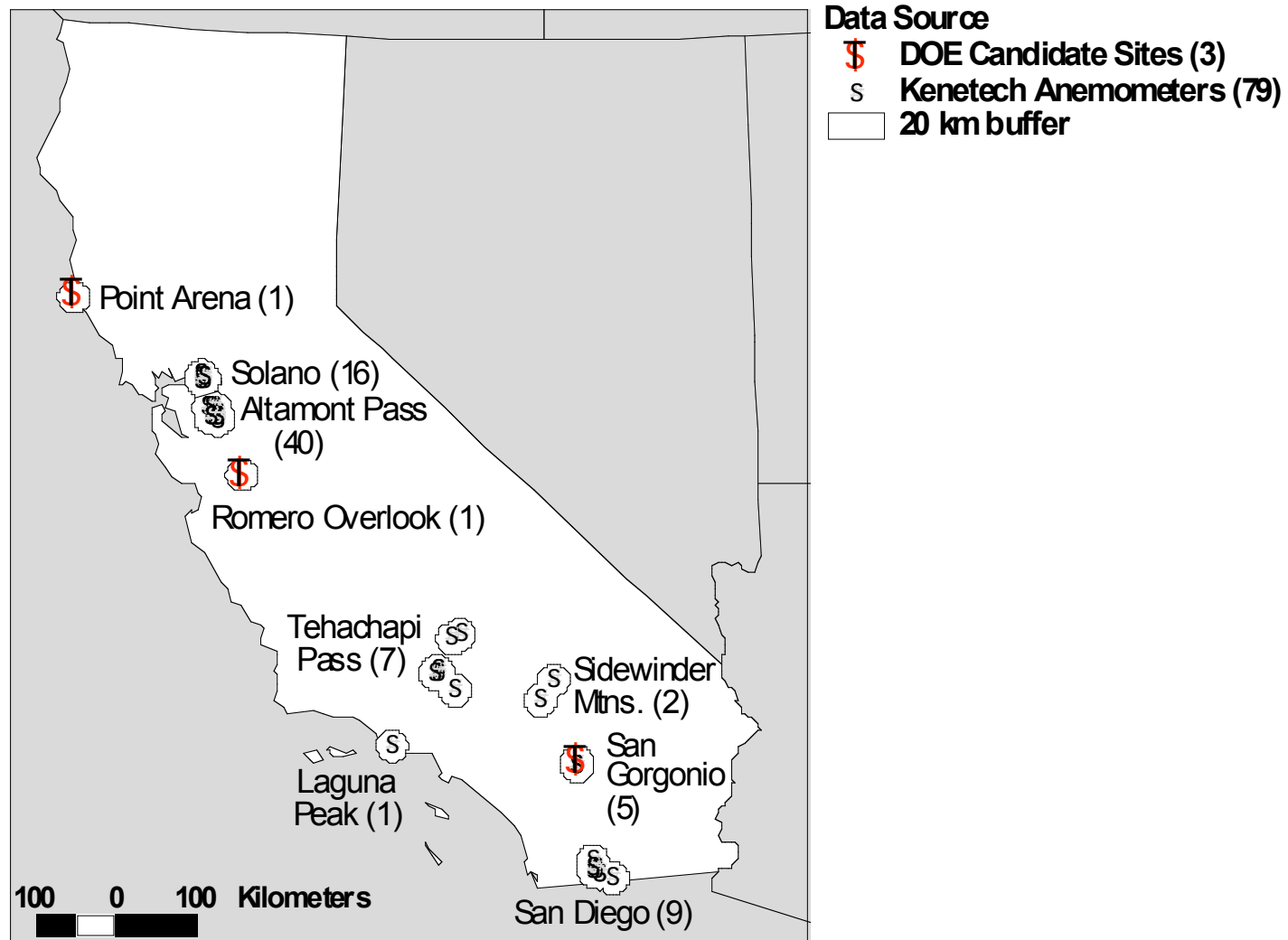
# Draft Berkeley Lab Report

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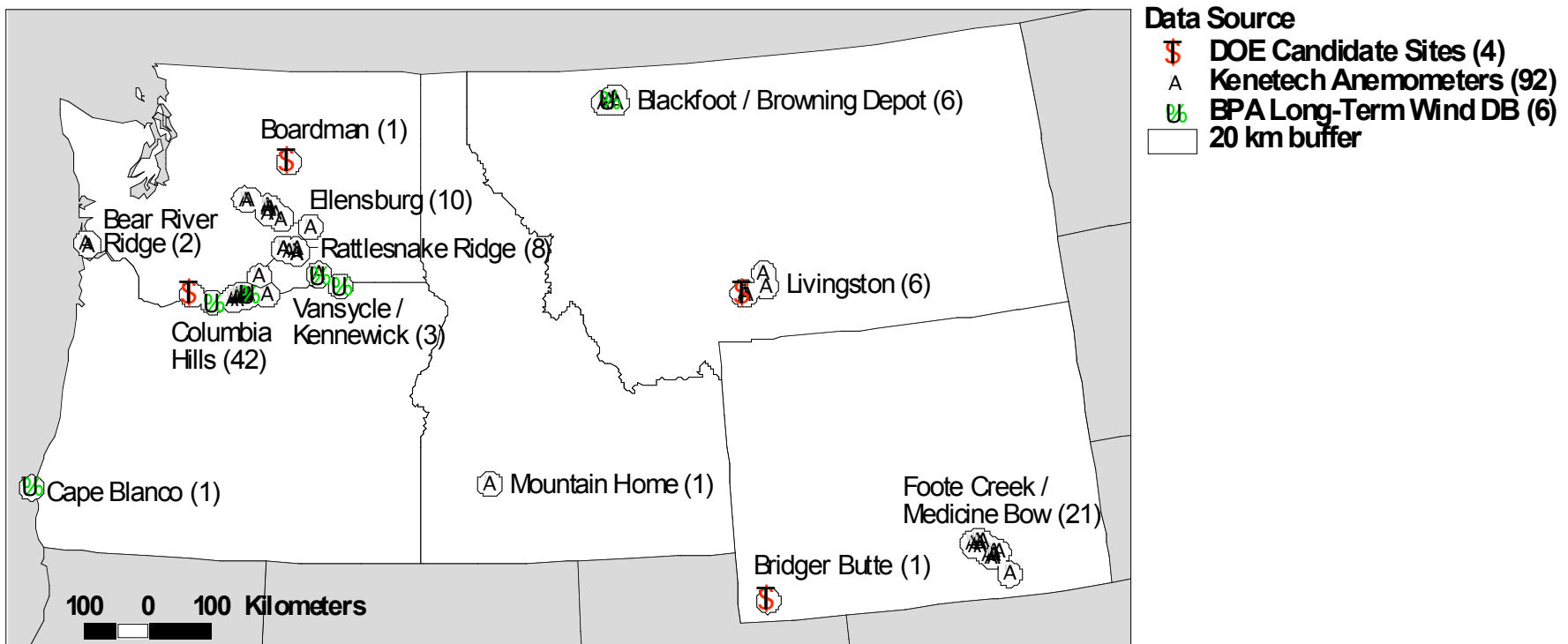
**Purpose:** Explore the correlation of temporal wind production patterns with peak electrical load and wholesale market prices in California and the Pacific Northwest (OR, WA, ID, MT, WY)

- **Data Sources**
    - TrueWind wind-speed estimates (main emphasis was to validate these data)
    - Anemometer measurements (secondary emphasis)
    - Actual hourly wind power production data (tertiary emphasis)
  - **Wind Value Metrics**
    - Capacity factor during top 10% of historic (2002-03) peak load hours in CA
    - Historic wholesale market value (historic PX prices, 1998-99)
    - Forecast wholesale market value (avg. 2006-13, CEC forecast from 2003)
  - **Key Limitation**
    - Relied primarily on TrueWind estimates at turbine hub-height and anemometer data well below hub height (actual production data limited)
    - These two datasets disagree, especially for California, and it is not clear which one is “right”
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# Defined California Resource Areas



# Defined Northwest Resource Areas



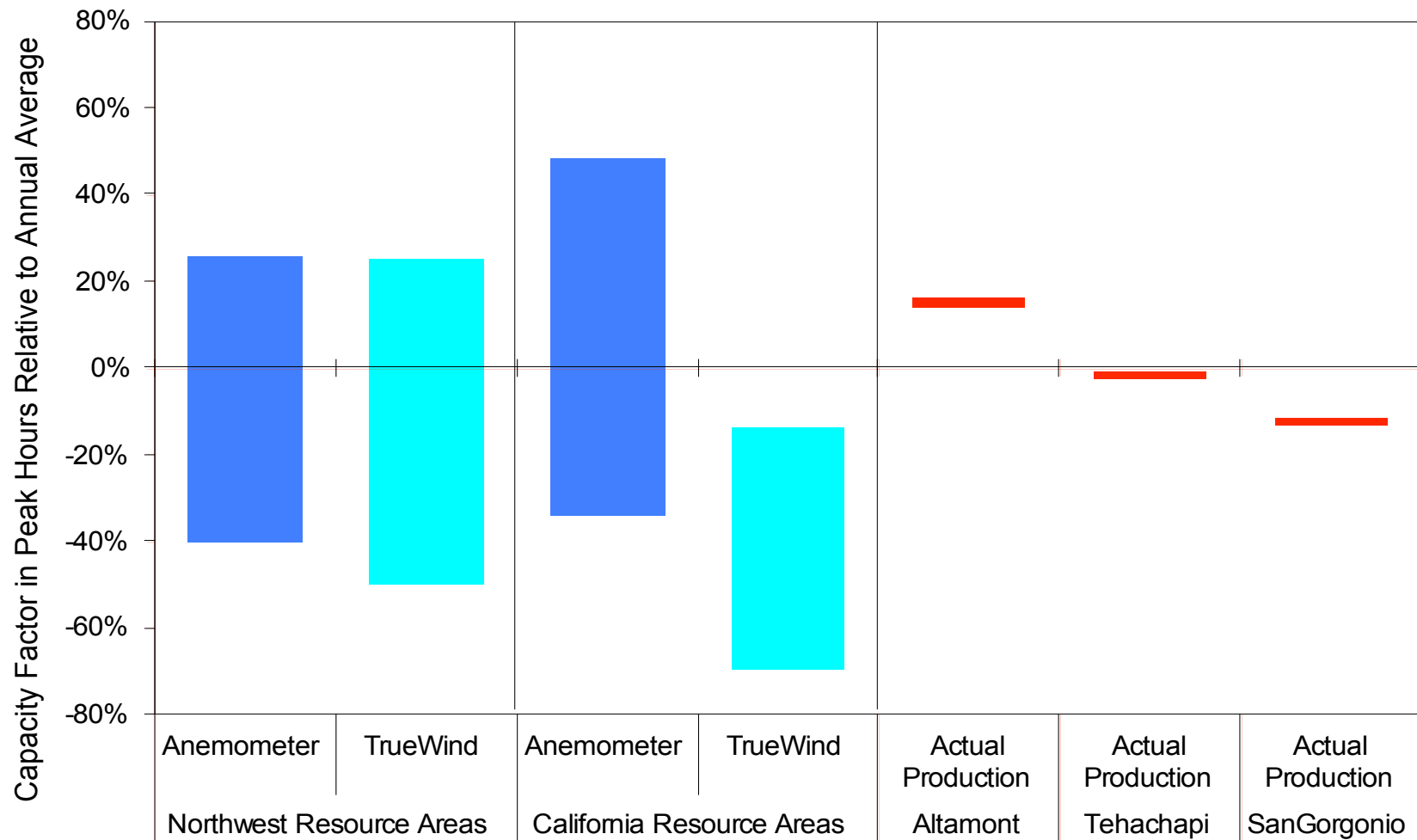
# Key Findings of the Draft Berkeley Lab Report

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- **Production During Peak Load Hours:** Wind sites with the most favorable temporal patterns may have capacity factors in the top 10% of peak load hours that are up to 50% higher than their annual average; poorly timed sites may have capacity factors that are as much as 50% below their annual average
  - **Wholesale Market Value:** Wind sites with the most favorable temporal patterns may have wholesale market value that is as much as 5% higher than a flat baseload block; poorly timed sites have wholesale value of as much as 10% below a flat baseload block
  - **Data Inconsistencies:** There is substantial disagreement among our three data sources on the relative standing of different resource areas, especially those in California
  - **California vs. Northwestern Sites:** There is little evidence that Northwestern wind sites will provide a significantly better match (than California wind sites) to California load or prices
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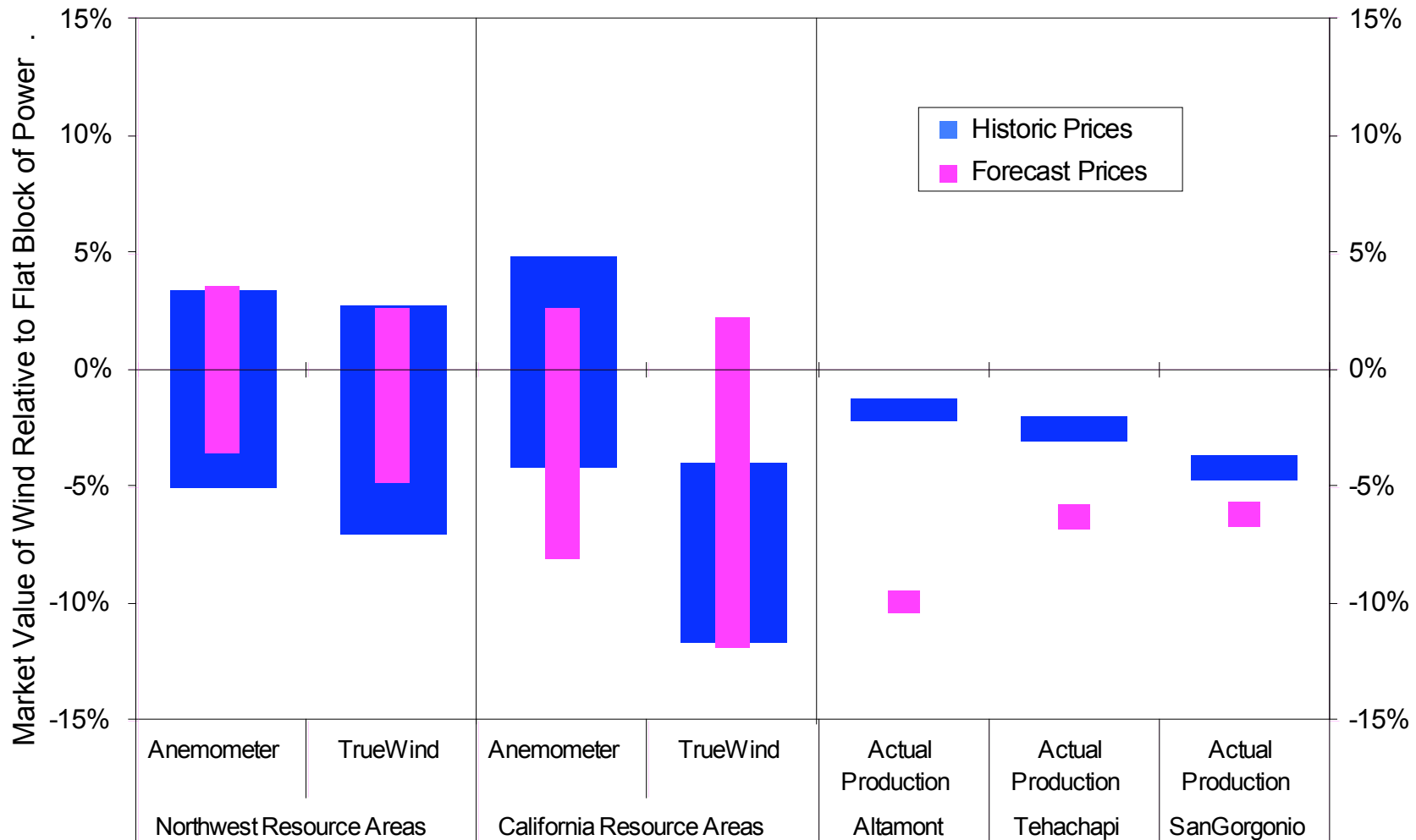


# Change in Capacity Factor in Top 10% of California's Peak Load Hours



*Graph shows range of median effects among defined resource areas; data for specific areas provided at end of presentation*

# Wholesale Market Value Relative to Flat Baseload Block



*Graph shows range of median effects among defined resource areas; data for specific areas provided at end of presentation*

# Conclusions

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- Temporal variations in wind patterns can affect the “value” of wind-generated electricity
    - But even the best- and worst-timed sites may have wholesale market value that is just 5% above or 10% below that of a flat block, respectively
  - California’s existing wind sites generally have relatively favorable monthly production patterns (peaking April-July), but relatively unfavorable diurnal patterns (peaking around midnight)
  - There is no broad resource area located in nearby Western states, and included in our analysis, that clearly has a ***dramatically better*** profile than California’s wind resource sites
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## **Additional Backup Slides**

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# Data Compilation

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- **Actual Wind Power Production**

- **CWEC Wind Integration Work:** Hourly aggregated production data for Altamont, San Geronio, and Tehachapi (year 2002)
- **FERC Quarterly Reports and EIA Form 906:** Monthly data for 1,600 MW installed in the West since 1999 (includes majority of newer projects, up to 4 years of data)

- **Project Developer Projections**

- **PPAs:** Data as revealed in power purchase agreements in Nevada (2), Washington (1), Wyoming (1), Idaho (1), and Montana (1)
- **IRPs:** Data included in utility integrated resource plans

- **Anemometer Data**

- **California:** Data records with over 1-year of data collection: Kenetech (79) and DOE Candidate Site (3) [\[embedded in Berkeley Lab Report\]](#)
- **Northwest:** Anemometer data with over 1-year of data collection: Kenetech (92), BPA (6), and DOE Candidate Site (5) [\[embedded in Berkeley Lab Report\]](#)
- **Other Western States:** Anemometer data from Kenetech and DOE Candidate Site for NV (14), NM (3), and CO (1); data generated for RMATS by NREL, using anemometer data to develop profiles for 14 wind resource areas in ID, WY, MT, CO, UT

- **TrueWind Estimates**

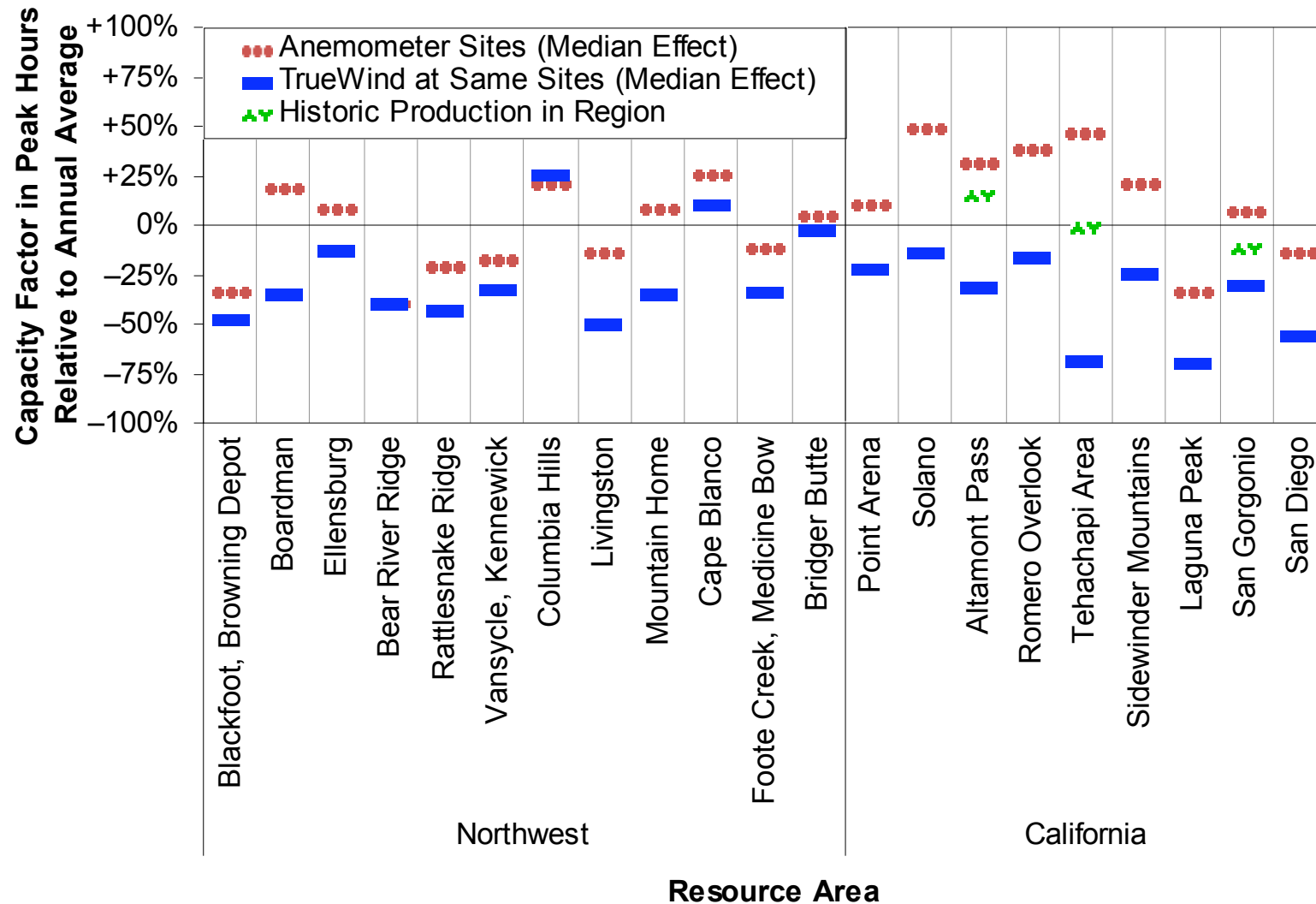
- Month-hourly (California) or season-hourly (Northwest) wind speed estimates for all of California and the Northwest [\[embedded in Berkeley Lab Report\]](#)
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# Data That We Did Not Use

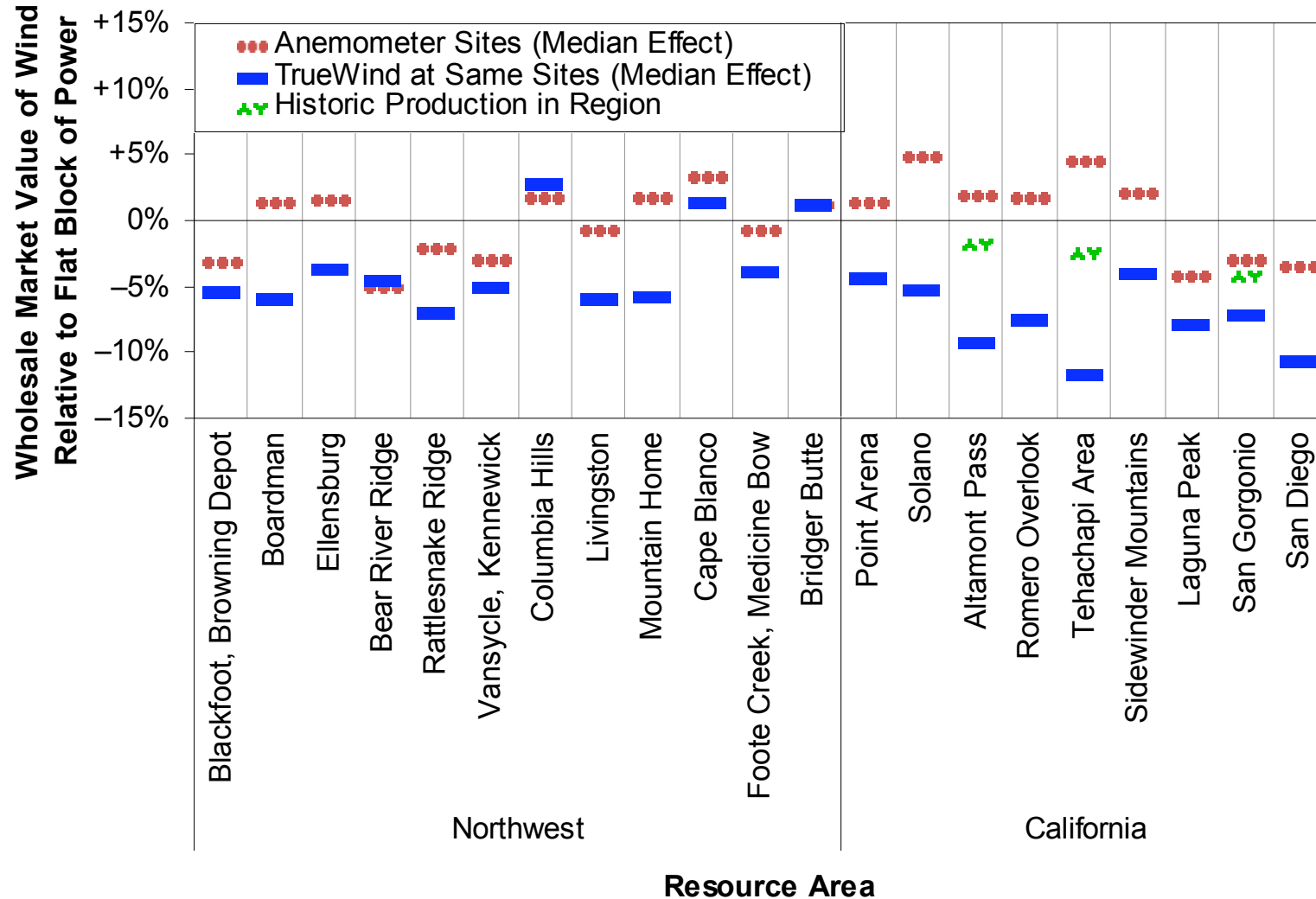
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- **FERC/EIA Monthly Production Data for Older Projects:** Assumed to be included in CWEC data on an hourly basis
  - **Actual Hourly Production Data from NREL:** NREL has actual production data from several Western wind projects, but those data are not available publicly
  - **Other Transmission Study Data:** Several Western transmission studies have used or are using wind profile data, often compiled from same anemometers that are already in our data set
  - **Other Anemometer Data:** Little value in collecting more such data at this time, for the purposes of this work scope
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# Change in Capacity Factor in Top 10% of California's Peak Load Hours, by Resource Area



# Wholesale Market Value Relative to Flat Baseload Block, by Resource Area (Historic Prices)





# Wholesale Market Value Relative to Flat Baseload Block, by Resource Area (Forecast Prices)

